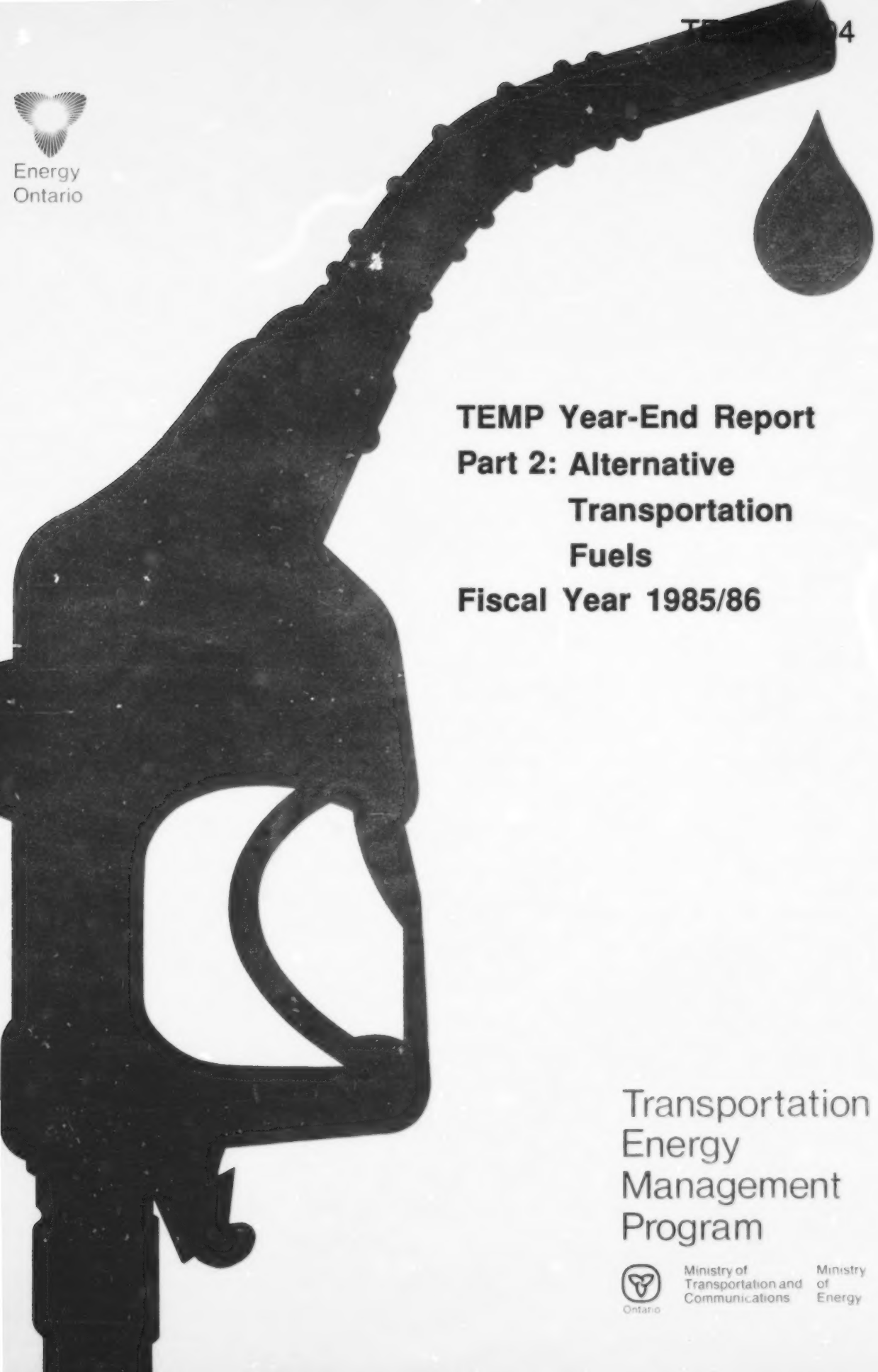
T[illegible]4

Energy
Ontario



# TEMP Year-End Report
# Part 2: Alternative Transportation Fuels
# Fiscal Year 1985/86

Transportation
Energy
Management
Program

Ontario
Ministry of Transportation and Communications
Ministry of Energy

# TEMP Year-End Report Part 2: Alternative Transportation Fuels Fiscal Year 1985/86

**O. Colavincenzo**
Manager
Automotive Technology and Systems Office

The Transportation Energy Management Program (TEMP) is a joint program of the Ministry of Transportation and Communications (MTC) and the Ministry of Energy (MENY) in which MTC is responsible for the program delivery of the utilization aspects of transportation energy.

The report was prepared by MTC's Automotive Technology and Systems Office to record TEMP's accomplishments during the past fiscal year.

Published by:
The Automotive Technology and Systems Office
The Transportation Technology and Energy Branch
Ontario Ministry of Transportation and Communications
Hon. Ed Fulton, Minister
D.G. Hobbs, Deputy Minister

Published without prejudice
as to the application of the findings.
Crown copyright reserved; however, this
document may be reproduced for non-commercial
purposes with attribution to the Ministry.

For additional copies, write:
**TEMP**
Room 324, Central Building
Ontario Ministry of Transportation and Communications
1201 Wilson Avenue
Downsview, Ontario
Canada M3M 1J8

**November 1986**

TABLE OF CONTENTS

PAGE

EXECUTIVE SUMMARY . . . . . v

1/ ALTERNATIVE TRANSPORTATION FUELS . . . . . 1
1.1/ Overview . . . . . 1

2/ PROPANE PROJECT REPORTS . . . . . 3
2.1/ Evaluation of Private Propane Vehicles (31505). . . . . 3
2.2/ Assessment of Propane-Butane Mixture as a Motor Fuel (31515) . . . . . 4
2.3/ Evaluation of the Dual Fuels Associates (DFA) Propane Mixer (31516) . . . . . 4
2.4/ Consolidation and Assessment of Propane Equipment Test Results (31523) . . . . . 5
2.5/ Propane Quality Analysis Program (31541). . . . . 5

3/ NATURAL GAS FOR VEHICLES (NGV) PROJECT REPORTS . . . . . 6
3.1/ Evaluation of NGV Use in Fleet Buses (Elgin County) (31504) . . . . . 6
3.2/ CNG Vehicle Testing and Evaluation (31507). . . . . 7
3.3/ In-Use Evaluation of CNG Home Compressor (31520). . . . . 7
3.4/ CNG School Bus engine Durability Test, Phase 1 (31545). . . 8

4/ ALCOHOL FUELS PROJECT REPORTS . . . . . 10
4.1/ MTC-Suncor-Alberta Gas Chemicals (AGC) Methanol-Gasoline Blend Vehicle Fleet Demonstration (31503) . . . . . 10

5/ DIESEL SUBSTITUTION PROJECT REPORTS . . . . . 11
5.1/ OC Transpo Propane Bus Demonstration (31500). . . . . 11
5.2/ Propane Conversion for Heavy Duty Trucks, Phase III (31502) . . . . . 11
5.3/ Hamilton Street Railway (HSR) Natural Gas Bus Demonstration, PHASE 1 (31501) . . . . . 12
5.4/ Hamilton Street Railway (HSR) Natural Gas Bus Demonstration, PHASE II (31517). . . . . 13
5.5/ ICG Propane Truck Demonstration (31551) . . . . . 14

6/ TECHNOLOGY DEVELOPMENT PROJECT REPORT . . . . . 15
6.1/ Transporter Development Contract, Phase II (31512). . . . . 15
6.2/ Aerodynamic Devices for Police Cruisers (31519) . . . . . 15

PAGE

7/ FUELS RESEARCH PROJECT REPORTS . . . . . 17
7.1/ Flammability Characteristics of Methanol Fuel Mixtures (31506) . . . . . 17
7.2/ MTC-Celanese Straight Methanol Vehicle Test (31508) . . . . 17
7.3/ Development of Adsorption Media for Improved Storage of Natural Gas (31509) . . . . . 18
7.4/ Adsorption Storage: Selection of Tank Design (31510) . . . 19
7.5/ Ford-Shell Methanol Vehicle Demonstration (31511) . . . . . 20
7.6/ Straight Methanol Carburetion: Cold-Start Performance, Phase II (31513). . . . . 20

8/ AUTOMOTIVE ENERGY ALLOCATIONS AND EXPENDITURES . . . . . 22
8.1/ Introduction . . . . . 22
8.2/ Financial Summaries . . . . . 23

## LIST OF TABLES

PAGE

1/ Alternative Transportation Fuels. . . . . 23
2/ Propane . . . . . 24
3/ Natural Gas . . . . . 24
4/ Alcohol Fuels . . . . . 25
5/ Diesel Substitution . . . . . 25
6/ Technology Development. . . . . 26
7/ Fuels Research. . . . . 26

## EXECUTIVE SUMMARY

The Alternative Transportation Fuels program is administered by the Automotive Technology and Systems Office of the Ministry of Transportation and Communications and is co-funded by the Ministry of Energy. This is a technical program with research, development, and demonstration components intended to facilitate the successful introduction and adoption of alternative fuels in the Ontario transportation sector.

The 1985/86 program consisted of 23 projects which were classified under the headings of propane, natural gas, alcohol fuels, diesel substitution, and fuels research. These projects were co-ordinated with the Energy Technology Development and Energy Technology Research Sections of the Ministry of Energy.

The 1985/86 fiscal year was a successful period for the Alternative Transportation Fuels program. There was greater private sector participation in the program than ever before, and a large number of technological and employment opportunities were created. The most notable additions to our list of partners are ICG Liquid Gas Ltd., Ontario Bus Industries, and the Cummins Engine Co. The MTC Automotive Energy Section is now spearheading the development and testing of propane and natural gas Cummins engines. The ICG propane truck demonstration will be the major beneficiary of the propane engine technology and will provide the mechanism for its introduction to the market place. The transit bus operators, including Hamilton Street Railway and Mississauga Transit, will be the first beneficiaries of the natural gas engine technology, and Ontario Bus Industries will market this technology in Canada and abroad.

In other projects, the natural gas adsorption technique was brought to a technically viable state; methanol-ethanol-gasoline blends, propane, and natural gas were demonstrated; alternative fuel bus engines, private fleet propane vehicles, and prototype natural gas vehicles were tested; and laboratory studies were conducted to advance alternative fuels and conservation technologies.

# 1/ ALTERNATIVE TRANSPORTATION FUELS

## 1.1/ Overview

The Alternative Transportation Fuels (ATF) program provides technical and scientific support to the Ontario government goals of reduced dependence on gasoline and diesel fuel, efficient transportation, and industrial expansion.

The fiscal year 1985/86 program consisted of 23 projects, 11 of which were performed with direct participation from the private sector, who contributed financially and/or provided specialized equipment, services, and expertise. Of the remaining projects, six were carried out in consultation with private sector and government partners. These partners included equipment or vehicle manufacturers, fuel suppliers, vehicle fleet operators, government agencies, universities, and research institutions.

Three main alternative fuels were considered:
1/ propane
2/ natural gas
3/ methanol

Activities in support of these fuels fall broadly into one of three categories:
1/ applied research
2/ technology development or improvement
3/ demonstration and fleet testing

At present, the ATF program is giving a high priority to the development of gas engines for the heavy-duty sector, comprising trucks and buses. Larger fuel consumption, higher pollution levels, and higher diesel fuel prices make propane and natural gas very attractive for this sector. Unfortunately, there is next to no gas engine technology available to support the conversion of these vehicles. Consequently, the MTC Automotive Energy Section continued and expanded its efforts to overcome this technological barrier. Specifically, the OC Transpo propane and Hamilton Street Railway (HSR) natural gas bus demonstrations were continued. An extensive bus engine comparative test program with six engines and four fuels was completed. The first generation Cummins Big-Cam propane engine was fully tested and demonstrated. Development of the second generation Cummins Big-Cam propane engine and the first generation Cummins L-10 natural gas engines were initiated.

In parallel projects, the fleet assessment of methanol-ethanol-gasoline blends was initiated. The reliability and durability of first-generation neat-methanol vehicles was assessed with Ford and Shell; improvements to the cold-starting performance of neat methanol were investigated with Celanese and the Royal Military College (RMC); and last but not least, combustion and vaporization characteristics of methanol fuels were investigated with RMC.

Low-pressure storage of natural gas was brought one step closer to reality by developing and testing highly adsorbent carbons. More than 40 private propane vehicles were tested to assess the status of the conversion technology. An aerodynamic light-bar for an Ontario Provincial Police (OPP) cruiser was developed and tested. A converted General Motors (GM) medium-duty engine was tested for durability at the Ontario Research Foundation (ORF) in a joint program with Union Gas.

As indicated, the Alternative Energy Section activities covered a wide spectrum of topics and numerous projects, which are more thoroughly covered in the body of this report. However, individual project reports and papers should be consulted for full details of project description and results.

## 2/ PROPANE PROJECT REPORTS

### 2.1/ Evaluation of Private Propane Vehicles (31505)

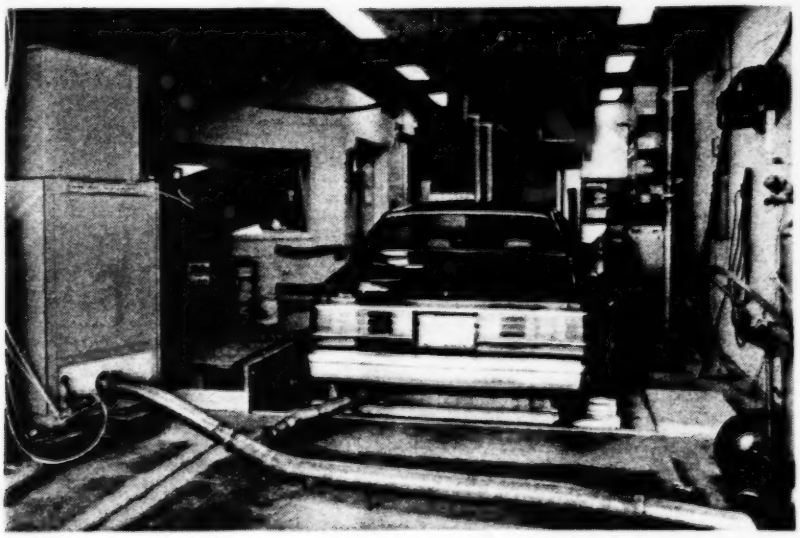
**Project Objective**
To assess overall effectiveness of privately owned cars and light trucks which have been converted from gasoline to propane.

**Activities**
A presentation was made to the TEMP DriveSave committee, outlining the project objectives and inviting participation from private industry.

Vehicles to be tested were initially checked on the engine analyzer for emissions timing, and a general inspection was conducted, relating to the propane conversion and vehicle condition. Chassis dynamometer tests were completed to determine fuel consumption and emissions. Air/fuel ratio measurements were also carried out in most cases.

**Results and Achievements**
Forty-five vehicles from 19 private companies and government agencies were tested. Results showed a wide variation in fuel consumption as compared to similar gasoline-powered vehicles, ranging from a low of approximately 18% more propane used to a high of 76% more propane used than gasoline. Results of these tests also indicate a relationship between good fuel consumption and good engine tuning practices. A complete internal report has been prepared. Production of a publishable report will necessitate further experimental and analytical work.

**Starting Date:** August 1, 1985 **Completion Date:** April 30, 1986



**Propane-powered vehicle being tested for fuel consumption and emissions on MTC's chassis dynamometer.**

## 2.2/ Assessment of Propane-Butane Mixture as a Motor Fuel (31515)

**Project Objective**
To establish technical guidelines which will facilitate the use of propane-butane mixtures as motor fuel in vehicles converted or designed to use automotive grade propane (LPG).

**Activities**
The R.F. Webb Corporation was contracted to carry out this study.

**Results and Achievements**
Findings led the consultant to conclude that it would be undesirable to employ butane-rich LPG mixtures in automobiles, both for vehicle performance reasons and refinery production reasons. The report recommends that automotive-grade LPG not be changed from the current specification.

**Starting Date:** August 1, 1985 **Completion Date:** March 31, 1986

## 2.3/ Evaluation of the Dual Fuels Associates (DFA) Propane Mixer (31516)

**Project Objective**
To determine the technical merits of this novel carburetor by assessing the propane consumption, exhaust emissions, and acceleration performance on the chassis dynamometer and driveability on the road.

**Activities**
A suitable vehicle was located and baseline tests on gasoline were performed using the MTC chassis dynamometer. The DFA propane mixer was then installed and the tests were repeated on gasoline and then on propane. A subjective evaluation of driveability was also done.

**Results and Achievements**
The results indicate that the mixer is capable of metering propane with reasonable precision without offering a significant restriction to engine intake airflow. A report of the results has been published and issued to IDEA Corporation, DFA, and Ontario Development Corporation.

**Starting Date:** February 1, 1985 **Completion Date:** March 31, 1986

## 2.4/ Consolidation and Assessment of Propane Equipment Test Results (31523)

**Project Objectives**
To prepare an overview and assessment for a three-volume technical report on propane engine tests performed by the University of Toronto, and to provide a consolidated, readable, and accessible report for general distribution to industry, government, and the technical public.

**Activities**
The proposal from the Mechanical Engineering Department of the University of Toronto was selected to prepare two technical reports based on the propane engine dynamometer results.

**Results and Achievements**
These reports have now been consolidated and are presently being prepared for publication.

**Starting Date:** December 1, 1985 **Completion Date:** March 31, 1986

## 2.5/ Propane Quality Analysis Program (31541)

**Project Objective**
To assess the quality of automotive-grade propane on the market in Ontario.

**Activities**
During the past year, eight propane samples were obtained from various retail outlets across Ontario. All samples were sent to the Technical Services Chemical Laboratory for analysis.

**Results and Achievements**
Laboratory analysis of the samples indicated propane content in excess of 96% in all cases. All other components were well within specifications.

**Starting Date:** January 1, 1985 **Completion Date:** March 31, 1986

## 3/ NATURAL GAS FOR VEHICLES (NGV) PROJECT REPORTS

### 3.1/ Evaluation of NGV Use in Fleet Buses (Elgin County) (31504)

**Project Objective**
To demonstrate the technical and economic feasibility of natural gas-powered buses in fleet service.

**Activities**
Thirty-five Elgin County school buses were converted to natural gas and have been running in daily service successfully during the past year.

**Results and Achievements**
A final report by the Elgin County School Board has been submitted to MTC for review and analysis. Considerable fuel cost savings of up to 50% have been claimed with the use of natural gas, along with a 30% reduction in overall operating cost during the last year. It is recommended that the Elgin County School Board report not be widely distributed, since its major findings and conclusions are unique and not generally applicable.

**Starting Date:** December 1, 1985 **Completion Date:** August 31, 1986

**Elgin County school buses connected to the slow-fill system are filled with natural gas directly from the compressor over an interval of several hours.**

### 3.2/ CNG Vehicle Testing and Evaluation (31507)

**Project Objective**
To determine fuel consumption, acceleration performance, exhaust emissions, and driveability characteristics of CNG-gasoline dual-fuel vehicles equipped with a conversion system commonly used in Ontario during both summer and winter conditions.

**Activities**
Additional summer baseline tests were conducted using a revised driving cycle which largely eliminates road testing variances induced by driver characteristics and vehicle position. A complete series of cold weather tests was conducted this past winter, which was used as a comparison to the summer baseline tests. Additional chassis dynamometer testing was completed on both test vehicles.

**Results and Achievements**
It was found that the fuel consumption of the gasoline-powered vehicle was higher than that of the natural gas-powered vehicle during the cold weather tests, whereas the opposite was true during the warm weather. The two vehicles had about the same fuel consumption when the temperature was 0°C (32°F).

The data from the road tests, along with the chassis dynamometer results, have been analyzed and are included in a draft report. This phase of the project is now complete.

**Starting Date:** April 1, 1985 **Completion Date:** March 31, 1986

### 3.3/ In-Use Evaluation of CNG Home Compressor (31520)

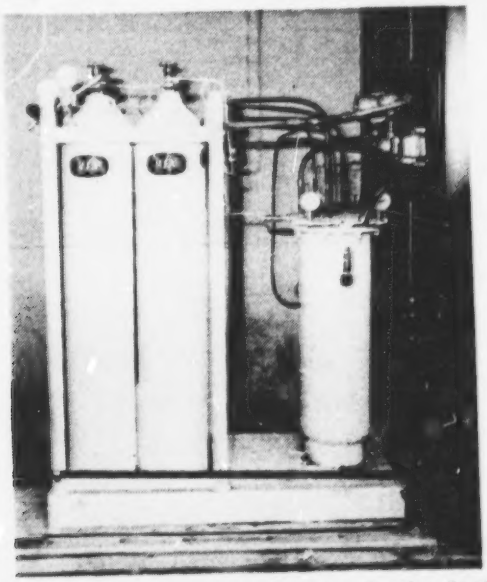
**Project Objective**
To assess and demonstrate technical and economic viability for CNG home refuelling with commercially available small compressor.

**Activities**
A NGV home compressor was purchased from RIX Industries and installed at the MTC Downsview complex. A number of electrical and mechanical modifications were required to obtain operating certificates from Ontario Hydro and the Pressure Vessels Safety Branch. Preliminary shakedown testing has been started to ascertain if all systems are functioning as required.

**Results and Achievements**
All modifications to the compressor and installation required by the regulating authorities have been completed. Initial shakedown tests indicate the compressor is operating to specifications.

Evaluation of the compressor operation itself will be completed during the next fiscal year. The final project report is due on or before March 31, 1987.

**Starting Date:** April 1, 1985 **Completion Date:** March 31, 1987



**Rix home compressor and storage tanks installed at MTC's Downsview complex.**

**3.4/ CNG School Bus Engine Durability Test, Phase 1 (31545)**

**Project Objective**
To document valve wear and operating costs for the GM 366 C/D school bus engine.

**Activities**
A contract was issued to ORF to test one engine on the GM accelerated wear test. A second engine has been installed in a GM suburban truck for evaluation by Union Gas.

**Results and Achievements**
ORF has completed the valve durability testing on the 366 CNG engine and a final report has been received. Results show substantial valve seat recession occurs; however, it is twice as bad when the positive valve rotators are operating. It is therefore desirable to disable valve

rotation on this engine when using natural gas. The fleet vehicle continues to be monitored.

**Starting Date:** January 1, 1986 **Completion Date:** March 31, 1987

## 4/ ALCOHOL FUELS PROJECT REPORTS

### 4.1/ MTC-Suncor-Alberta Gas Chemicals (AGC) Methanol-Gasoline Blend Vehicle Fleet Demonstration (31503)

**Project Objective**
To evaluate the acceptability, in a fleet of 40 MTC cars, of a refinery-supplied methanol-gasoline blend designed to minimize co-solvent usage.

**Activities**
Driveability testing, fuel sampling, and oil sampling activities have continued during the past fiscal year. A new methanol-gasoline blend with ethanol as a co-solvent has been devised by Suncor and AGC. Chassis dynamometer testing for fuel consumption, exhaust emissions, and air/fuel ratio checks have been performed.

**Results**
Vehicle operations using the new fuel blend has been satisfactory, with no unacceptable driving performance reported during the winter months. No further incidents of phase separation have occurred during the past year. A report documenting results obtained during the first two years has been completed and is now being published.

**Starting Date:** June 1, 1984 **Completion Date:** March 31, 1987

## 5/ DIESEL SUBSTITUTION PROJECT REPORTS

### 5.1/ OC Transpo Propane Bus Demonstration (31500)

**Project Objectives**
To demonstrate the practicability of operating a transit fleet of propane-powered buses. To obtain information on reliability, operating costs, and public acceptance.

**Activities**
Ten buses have now been fitted with propane engines, fuel tanks, and associated hardware. An on-site propane storage and fuelling facility has been installed at OC Transpo. One bus was tested for relative noise and vibration levels compared to the standard diesel-powered vehicles. During the winter months no cold-start problems were encountered, and recent problems with the crankcase venting system have been solved.

**Results and Achievements**
All propane buses ran relatively free of propane-related problems while in revenue service over the last three months. The data acquisition system for monitoring the performance of the buses is now fully operational. A high-capacity fuelling system is now operational, and a fuelling time of four minutes per bus has been attained.

**Starting Date:** January 1, 1983 **Completion Date:** March 31, 1987

### 5.2/ Propane Conversion for Heavy-Duty Trucks, Phase III (31502)

**Project Objective**
To road test the heavy-duty propane-powered tractor-trailer combination developed in Phase II to obtain information on reliability and operating costs.

**Activities**
The truck was successfully operated in revenue service for the seven-month period ending December 31, 1985. Incidences of valve sticking and backfiring were the only problems experienced during the test period. and these problems were successfully handled during the term of the demonstration. Cold-starting and running tests were completed over the winter months. The vehicle was displayed at a major trucking show, where it attracted a great deal of interest.

**Results and Achievements**
Fleet testing in service by Manitoulin Transport was completed in December 1985. Driver comments were very favourable. The truck has

generated a lot of interest within the trucking industry and has been written up in several trade magazines. A report documenting vehicle performance and reliability in fleet operation is in its editorial stage.

**Starting Date:** September 1, 1984 **Completion Date:** March 31, 1986

**Western Star heavy-duty truck converted to operate on propane.**

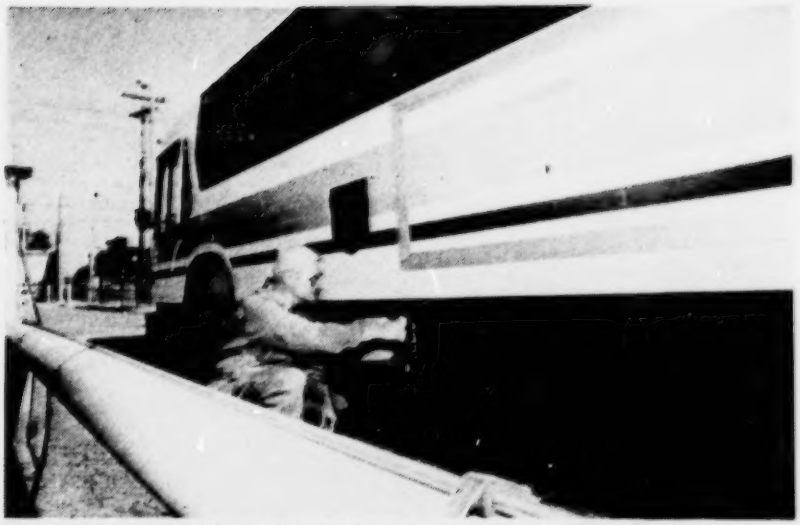
### 5.3/ Hamilton Street Railway (HSR) Natural Gas Bus Demonstration, PHASE 1 (31501)

**Project Objective**
To determine the technical feasibility of operating transit buses on natural gas by conducting a vehicle test under controlled conditions.

**Activities**
Formal liaison with project participants via a steering committee has been established.

**Results and Achievements**
One bus was converted to operate on natural gas using the Dereco (IVECO) NGV engine. An optimal go/no-go test was conducted to varify vehicle suitability for revenue service, with respect to fuel economy, range, gradability, and acceleration performance. The bus passed this test with flying colours, which led to the approval of the second phase of the project (Project 31517), in which the operational performance of a six-bus fleet running on NGV will be assessed.

**Starting Date:** April 4, 1985 **Completion Date:** November 30, 1985



**Refuelling Hamilton Street Railway's first natural gas-powered transit bus.**

## 5.4/ Hamilton Street Railway (HSR) Natural Gas Bus Demonstration, Phase II (31517)

**Project Objectives**

To demonstrate the potential of natural gas as a transit bus fuel. To obtain information on reliability, operating costs, and public acceptance.

**Activities**

A standard 40 ft transit bus has been converted to accept a Dereco natural gas engine. A large natural gas refuelling facility has been designed and built and is now fully operational. The bus has been entered into revenue service, together with a second bus equipped with a four-stroke diesel engine for comparison purposes. Several modifications have been carried out on the natural gas regulator-mixer system to achieve an improved engine operation. The natural gas engine has been tested at the Ontario Research Foundation (ORF), in the engine dynamometer, to establish its fuel consumption, performance, and exhaust emissions characteristics.

**Results and Achievements**

One transit bus is operating successfully on natural gas. A large refuelling facility is now in operation. Public acceptance of the bus has been good, and five additional buses are now in the process of being converted to natural gas.

**Starting Date:** December 1, 1985 **Completion Date:** March 31, 1987

## 5.5/ ICG Propane Truck Demonstration (31551)

**Project Objective**

To demonstrate a domestic diesel engine, converted to run on propane, in a class 8 heavy-duty highway tractor, by converting two tractors, one for revenue service in ICG's fleet, and the other for truck shows, conferences, and seminars and for loan, for short periods of time, to prospective propane truck operators.

**Activities**

1/ Convert the first tractor to propane using the engine developed as part of an earlier program
2/ Develop a second (new) engine at ORF and install it into the second tractor.
3/ Rebuild a third engine at a heavy-engine rebuild shop to propane specifications, and swap it with the original engine from the first tractor.
4/ Both tractors will enter ICG fleet operation and the publicity campaign upon completion.

**Results and Achievements**

The first tractor has been converted to propane.

**Starting Date:** March 1, 1986 **Completion Date:** March 31, 1988

**ICG's first propane-powered heavy-duty highway tractor.**

## 6/ TECHNOLOGY DEVELOPMENT PROJECT REPORT

### 6.1/ Transporter Development Contract, Phase II (31512)

**Project Objectives**
To further develop the transporter by using the wheel and rail principle and to provide a preliminary system design of all the elements of a complete transportation system, including estimated costs and performance. To assess market viability.

**Activities**
The work was started in mid-December 1985, and by February 4, 14 reports were issued on various tasks. A meeting was held between Transportation Technology Limited (TTL) and MTC on February 28 to discuss these reports.

**Results and Achievements**
Draft final reports are due in April 1986.

**Starting Date:** January 15, 1985 **Completion Date:** August 30, 1986

### 6.2/ Aerodynamic Devices for Police Cruisers (31519)

**Project Objective**
To investigate means of reducing fuel consumption in OPP vehicles equipped with light-bars by lowering aerodynamic drag.

**Activities**
Extensive wind tunnel testing carried out at the National Research Council's (NRC's) 10 m low-speed wind tunnel in Ottawa enabled development of a low-drag light-bar configuration for the OPP. The first demonstration light-bar was constructed, and a preliminary evaluation indicated that the wind noise level was too high at 100 km/h. After extensive testing was performed, further refinements were made, which has reduced the wind noise to within one decibel of the standard OPP bar. Chassis dynamometer testing was also conducted at MTC to determine potential fuel savings with the new bar design as compared to the standard OPP cruiser.

**Results and Achievements**
A prototype light-bar has been built for the OPP, and initial test results indicate that a saving in fuel costs of up to 5% is possible.

During the next fiscal year the first prototype bar will be installed on a new police cruiser and entered into trial service for a six-week

assessment. Upon receiving approval by the OPP of the new light-bar, a 24-vehicle demonstration will be performed. Operational performance and performance and fuel costs will be closely monitored and compared to the conventionally equipped OPP vehicles.

**Starting Date:** April 1, 1985 **Completion Date:** March 31, 1987

**Prototype aerodynamic light-bar mounted on an OPP cruiser.**

## 7/ FUELS RESEARCH PROJECT REPORTS

### 7.1/ Flammability Characteristics of Methanol Fuel Mixtures (31506)

**Project Objective**
To determine the flammability and flame propagation properties of methanol fuel-air mixtures.

**Activities**
At Royal Military College laboratories, apparatus have been devised and experiments conducted to determine the vapour composition of partially evaporated fuels. Fuel samples were supplied by MTC, containing gasoline and dimethyl ether as volatility primers to aid starting at low temperatures. The rapid compression machine has been modified to conduct experiments in flame propagation through fuel mists.

**Results and Achievements**
A draft report has been received giving a detailed theoretical discussion of the modelling of flame propagation. The project is now completed.

**Starting Date:** January 1, 1985 **Completion Date:** March 31, 1986

### 7.2/ MTC-Celanese Straight Methanol Vehicle Test (31508)

**Project Objective**
To examine the performance of two methanol vehicle designs when used with oxygenated (methanol-derived) volatility primers to aid cold starting and to examine the wear of one vehicle under a long-term distance accumulation.

**Activities**
A Ford Escort and a VW Golf instrumented for cold-start testing have been used to determine if adequate low-temperature startability could be obtained using fuels formulated by Celanese, containing only oxygenated components dimethoxy methane and dimethyl ether as volatility primers. A second Ford Escort has continued to accumulate distance to determine long-term wear of engine components. The engine of this long-term durability vehicle has been stripped down after 30 000 km and examined.

**Results and Achievements**
Results of the engine teardown showed that, with few exceptions, component dimensions were within the manufacturer's acceptable tolerances after the distance accumulation.

The first round of fuels tested for cold starting did not extend startability beyond that achieved with M90 (methanol, 90%; gasoline, 10%). A second round of tests is now being carried out using up to twice the concentration (6%) of volatility primers. A comprehensive report (AF-86-01) has been issued.

**Starting Date:** April 1, 1985 **Completion Date:** October 30, 1986

**Ford Escort ready for testing in cold-start chamber.**

### 7.3/ Development of Adsorption Media for Improved Storage of Natural Gas (31509)

**Project Objective**

To investigate the adsorption performance of selected prepared carbons in storing compressed natural gas.

**Activities**

A transportable gas cylinder system was constructed capable of being refilled with compressed natural gas from a commercial outlet in the Kingston area. This was used to supply commercial-grade natural gas for repeated fill-empty cycles at pressures to 6.9 MPa (1000 psia) conducted on various adsorbent compositions. Saran and Saran composite material have been prepared and tested in the search for improved storage capacity.

**Results and Achievements**
Results of the fill-empty cycling with commercial-grade natural gas showed a lowering of the delivered amount of gas due to impurities. New composite materials made by combining Saran with other carbons indicated an improved level of gas delivered on desorption, compared with Saran itself. The final report on this phase of the project has been issued.

**Starting Date:** August 1, 1985 **Completion Date:** March 31, 1986

**Sample of Saran carbon developed for low-pressure storage of natural gas.**

**7.4/ Adsorption Storage: Selection of Tank Design (31510)**

**Project Objective**
To select a design pressure for the storage of CNG in adsorbent materials and to design distributed tank systems for three representative vehicles.

**Activities**
The consultant company, DSMA-ATCON, contracted to do the work, declared bankruptcy and all work ceased. No report was received or paid for and the contract was cancelled by letter from MTC.

**Results and Achievements**
A new consultant will be selected in the next fiscal year to carry out the work of designing a tank system to contain the carbon blocks developed under project 31509.

**Starting Date:** April 1/ 1986 **Completion Date:** March 31, 1987

**7.5/ Ford-Shell Methanol Vehicle Demonstration (31511)**

**Project Objective**
To test the engine durability and wear resistance of factory-supplied methanol-fuel vehicles using new oil formulations.

**Activities**
Three methanol-designed cars were stripped down and their engines pre-measured before entering a long-trip distance accumulation mode. Another seven vehicles were also started in the same operating regime. Special oil formulations are being used, and regular sampling and analysis of the used oil has taken place to monitor changes in bulk properties and trace metals arising from engine wear.

**Results and Achievements**
The project was completed with the stripping of the three engines, which were then measured for accumulated wear. A final report was received and is being reviewed.

**Starting Date:** April 1, 1985 **Completion Date:** March 31, 1986

**7.6/ Straight Methanol Carburetion: Cold-Start Performance, Phase II (31513)**

**Project Objective**
To examine the physical phenomena occurring during cold start-up of an automotive methanol engine and to identify engine design features and fuel quality specifications that will extend the low-temperature startability.

**Activities**
A Ford Escort methanol engine was acquired and installed in a cold chamber instrumented to monitor various parameters during cold starting. Seven fuel formulations were supplied by Shell, containing various proportions of gasoline and dimethyl ether as additives to enhance volatility. Data generated are being used to develop a computer model of the engine starting process.

**Results and Achievements**

Starting has been achieved on the bench-mounted methanol engine at very low temperatures (e.g., -37°C) using fuels enhanced with dimethyl ether or butane. This is mainly due to the prolonged cranking times and the optimized air/fuel ratio achieved for a bench-mounted engine. However, it suggests the possibility of improved low-temperature startability over that presently achieved in vehicles (-20°C). Mathematical modelling of the flow and evaporation of the fuel during the cold-start process has been performed to determine the engine design and fuel composition factors that affect cold startability. A final report has been received.

**Starting Date:** August 1, 1984 **Completion Date:** March 31, 1986

# 8/ AUTOMOTIVE ENERGY ALLOCATIONS AND EXPENDITURES

## 8.1/ Introduction

The following pages summarize the funding allocations and expenditures for the Automotive Energy Section of the Transportation Energy Management Program for FY 1985/86. The majority of the funding is that portion allocated by the Ministry of Energy for direct operating expenditures, including consultant and university services, purchase of goods and equipment, and the direction of seminars. The tables on the following pages show the initial Ministry of Energy allocation as well as the final, actual expenditure.

The Ministry of Transportation and Communications' expenditure includes staff resources, data processing, travel, and administrative costs. The tables do not include MTC expenditures by offices other than Automotive Technology and Systems Office, even in cases where other offices incurred cost working on, or in support of, Automotive Energy projects.

Table 1 provides a general overview, while Tables 2 to 7 detail allocations and expenditures by project. The data presented in these tables have not been audited but are considered to be accurate.

## 8.2/ Financial Summaries

**Table 1/ Alternative Transportation Fuels**

| Project Title | MENY Alloc. | MENY Final Expenditure | MTC Final Expenditure |
|---|---|---|---|
| Transportation Energy Technology | | | |
| Propane | 64.0 | 58.5 | 26.5 |
| Natural Gas | 45.0 | 45.5 | 20.5 |
| Alcohol Fuels | 30.0 | 32.1 | 29.2 |
| Diesel Sub. | 395.0 | 439.4 | 25.1 |
| Technology Dev. | 109.0 | 102.0 | 112.3 |
| Research and Development | | | |
| Fuel Research | 208.2 | 175.2 | 27.1 |
| Total | 851.2 | 852.7 | 240.7 |

**Table 2/ Propane**

| Project Number | Project Name | MENY Alloc. | MENY Final Expenditure | MTC Final Expenditure |
|---|---|---|---|---|
| 31505 | Evaluation of Private Propane Vehicles | 7.0 | 7.4 | 17.2 |
| 31515 | Assessment of Propane-Butane Mixtures | 30.0 | 29.4 | 3.1 |
| 31516 | Evaluation of Dual Fuels Propane Carburetor | 2.0 | 1.6 | 5.5 |
| 31523 | Consolidation of Propane Equipment Test Results | 25.0 | 20.1 | 0.7 |
| 31541 | Propane Quality Analysis Program | 0.0 | 0.0 | 3.0 |
| Total | | 64.0 | 58.5 | 29.5 |

**Table 3/ Natural Gas**

| Project Number | Project Name | MENY Alloc. | MENY Final Expenditure | MTC Final Expenditure |
|---|---|---|---|---|
| 31504 | School Bus Fleet NGV Demonstration | 5.0 | 0.0 | 2.8 |
| 31507 | NGV Testing and Evaluation | 10.0 | 10.7 | 9.7 |
| 31520 | Evaluation of NG Home Compressors | 10.0 | 15.9 | 8.0 |
| 31545 | NGV School Bus Engine Development | 20.0 | 18.9 | 0.0 |
| Total | | 45.0 | 45.5 | 20.5 |

**Table 4/ Alcohol Fuels**

| Project Number | Project Name | MENY Alloc. | MENY Final Expenditure | MTC Final Expenditure |
|---|---|---|---|---|
| 31503 | MTC-Suncor Methanol Fleet Demo. | 30.0 | 32.1 | 29.2 |
| Total | | 30.0 | 32.1 | 29.2 |

**Table 5/ Diesel Substitution**

| Project Number | Project Name | MENY Alloc. | MENY Final Expenditure | MTC Final Expenditure |
|---|---|---|---|---|
| 31500 | OC Transpo Propane Bus Demonstration | 135.0 | 161.7 | 10.6 |
| 31501 | HSR Natural Gas Bus Demo, Phase 1 | 50.0 | 50.1 | 8.2 |
| 31502 | Diesel/Propane Conversion for Heavy Trucks, Phase III | 60.0 | 59.8 | 4.8 |
| 31517 | HSR Natural Gas Bus Demo., Phase II | 120.0 | 137.8 | 1.5 |
| 31551 | ICG-MTC Propane Truck Demonstration | 30.0 | 30.0 | 0.0 |
| Total | | 395.0 | 439.4 | 25.1 |

**Table 6/ Technology Development**

| Project Number | Project Name | MENY Alloc. | MENY Final Expenditure | MTC Final Expenditure |
|---|---|---|---|---|
| 31512 | UTDC Transporter | 89.0 | 88.8 | 94.0 |
| 31519 | Aerodynamic Devices for Police Cruisers | 20.0 | 13.2 | 18.3 |
| Total | | 109.0 | 102.0 | 112.3 |

**Table 7/ Fuels Research**

| Project Number | Project Name | MENY Alloc. | MENY Final Expenditure | MTC Final Expenditure |
|---|---|---|---|---|
| 31506 | Flammability Characteristics of Methanol Fuel Mixtures | 19.0 | 19.1 | 0.5 |
| 31508 | MTC-Celanese Methanol Vehicle Test | 10.0 | 11.9 | 9.3 |
| 31509 | CNG Adsorption Storage Materials Development | 50.0 | 47.2 | 6.2 |
| 31510 | CNG Adsorption Storage Equipment Development | 30.0 | 0.0 | 4.0 |
| 31511 | Ford-Shell Methanol Vehicle Demonstration | 67.2 | 66.3 | 3.8 |
| 31513 | Methanol Cold-Start Performance, Phase II | 32.0 | 30.7 | 3.3 |
| Total | | 208.2 | 175.2 | 27.1 |